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INTERDISCIPLINARY APPLICATIONS AND INTERPRETATIONS of ERTS DATA WITHIN THE SUSQUEHANNA RIVER BASIN

Resource Inventory, Land Use, Pollution

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Contract NAS 5-23133
ERTS Investigation 082
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1082AA (UN 159)

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1082A

I. PROGRESS ON TASKS

Inventory of Natural Resources and Land Use

Dr. Petersen has held preliminary discussions with personnel at the University of Wisconsin concerning two research projects which may be initiated during his sabbatical leave. (Dr. Petersen will spend a year at the University of Wisconsin, starting in June of this year.) One of these studies will involve the monitoring of hydrologically active source areas, using remote sensing techniques. Several study sites are being considered, and it is planned that aircraft and thermal data will be used. The second study involves digitization of aerial photographs in an effort to classify the data to produce land cover maps. This work will be done in cooperation with Penn State, involving a preliminary analysis of the digitized data by ORSER.

Geology and Hydrology

ORSER is involved in ongoing studies of the applications of lineaments, observed on Skylab and ERTS images, to groundwater exploration and problems in geologic engineering. It has been recognized that prolonged investigations would be required to demonstrate the significance of lineaments to groundwater and foundation engineering investigations because:

1. The width of subsurface structural features causing lineaments to be visible is not known.

2. Direct observation of these structures is limited in heavily forested regions of the humid eastern United States, where soil overburden typically mantles the bedrock.

3. It is difficult to locate with precision on the ground the lineaments seen on satellite images. Thus a comparison of the performance of known water wells, foundations, mine roofs, etc., on and off lineaments becomes difficult.

Most water well records available for study in Pennsylvania which are on file with the Pennsylvania Geological Survey include "hear say" data reported by the well owner or water well contractor. Frequently, wells are not located where they are reported to be located, formations penetrated and lithologies encountered are not reported or incorrectly reported, and yield tests are run in such a manner that the decline in water levels required to produce a given yield are not reported.

An alternate source of data may be obtained using well inventory procedures involving a door-to-door survey of well owners. However, rarely do well owners have records or knowledge of information such as their well depth, casing lengths, pump setting, water levels. Still worse, even if permission is granted to conduct pumping tests, provisions may be lacking to allow drawdown determinations to be made.

Many well owners fear that they will run out of water during such tests, and therefore restrict the test. Some wells lack pumps and require the setting and pulling of test pumps. Contracts for these services, including pump rental with water well contractors, may run between $25.00 to $75.00 per hour, depending upon the pump size used. These costs are prohibitive in view of research budget limitations.

A final data source may be obtained by providing assistance to landowners, towns and industries either as an extension service or through consulting activities--where well sites may be selected, test and production wells designed, and drilling and yield testing services conducted under controlled and supervised conditions. This procedure yields data of high quality but is time consuming, because there is no assurance that a recommended well site will be drilled out. Further, there is no way to assure that well yields will be clustered adequately within any hydrogeological setting to allow statistical analysis.

Many factors combine to influence well yields at a particular location (well radius, depth and diameter; casing length and method of drilling; degree of well development and depth to water table; rock type and various changes of rock type; dip of beds, rock structure, and topographic setting; presence and type of joints and faults; number and type of zones of fracture concentration; etc.). Comparison of yields of but a few wells on or off a lineament will not suffice to establish significant relationships or to determine the magnitude of yield increases. Similar variables influence the depth and extent of weathering, of importance in engineering foundation studies, mine and tunnel roof stability, etc.

The difficulties encountered in establishing ground truth correlation for lineaments seen on ERTS and Skylab scenes are many, and even more problems are associated with determining the usefulness of these features for groundwater and mineral exploration. However, Skylab and ERTS data have revealed the universality of lineaments as structural features of the earth's crust, and investigations to date indicate their potential significance in resource exploration.

Graduate student Melvin H. Podwysocki has completed work begun in the Fall of 1973 on an assistantship from ORSER's ERTS program. The results of his work have been published as GSFC Document X-644-74-3, "Fortran IV Programs for Summarization and Analysis of Fracture Trace and Lineament Patterns." In this project, three FORTRAN IV programs were written to facilitate the manipulation of the large number of observations involved in the analysis of lineament and fracture trace patterns. The TRANSFORM program converts the initial fracture map data into a format compatible with the program AZMAP, which has options permitting repetitive manipulation of the data for optimization of the analysis. The ROSE program creates rose diagrams of the fracture patterns suitable for map overlays and tectonic interpretation. Examples are given and further analysis techniques using output from these programs are discussed.

Ground truth mapping of the Bald Eagle ridge from north of Bellefonte to south of Tyrone has been started. Part of this study is to ascertain the effect of ERTS lineaments where they are mapped as crossing the quartzites of the Tuscarora and Juniata formations along the ridge crest. The road cuts exposed by highway construction for a few miles north of Tyrone were mapped on aircraft imagery supplied by HRB Singer and flown for The Pennsylvania Department of Transportation.

Work is continuing on the analysis of glacial deposits in northwestern Pennsylvania. Data subset from two ERTS scenes (1029-15354 and 1226-15305) have been used to run NMAP and UMAP programs, to determine brightness and uniformity, respectively. The STATS program will be used to determine training areas for classification purposes, after which the data will be analyzed by supervised and non-supervised classification methods.

A project to evaluate ERTS and underflight imagery for geologic mapping was initiated by several students in a Remote Sensing course offered in the Geosciences Department by D. P. Gold. Each student, with a "groundtruth" knowledge of a specific area, used various scales of ERTS imagery to interpret structure and geology. The preliminary results have been unexpectedly good, and negated some earlier reservations concerning the use of ERTS imagery for geologic mapping. The results of these studies will be summarized in a technical report.

Environmental Quality

A project jointly funded by NASA, through ORSER, and the U. S. Forest Service, through the Penn State Agricultural Experiment Station, has shown that at least two levels of gypsy moth defoliation can be detected from ERTS data and mapped effectively. Ground truth for this project was supplied from the Pennsylvania Bureau of Forestry and the U. S. Forest Service.

Through good fortune, two cloud-free ERTS scenes were made over the defoliated area in east central Pennsylvania on July 8, 1973, the height of the defoliation period. Although such an occurrence with the present ERTS passes of 18 days, many of which are cloud-covered, could not be expected to occur each year, this limitation could be overcome if future satellite systems result in more frequent coverage.

Cluster analysis of ERTS data for the Palmerton area, site of air pollution by a zinc smelter, has revealed that the area can be divided into four distinct types: 1) healthy forest, 2) less healthy forest (thinner, with less undergrowth), 3) forest in poor condition (mostly sassafras and black gum trees with a few scattered oaks and no undergrowth), 4) barren soil with severe erosion and Arenaria patula as the only vascular plant growth.

Data Processing

In preparation for work on the General Electric Image 100 system, development and implementation of software to generate non-standard data tapes in ERTS format has begun. The Image 100 system will accept only ERTS format tapes of four channels at 800 BPI. Non-ERTS MSS tapes are currently available in a number of formats, such as MSS-DAS[1], LARSYS II[2], etc. The program library at ORSER contains a number of programs which use data from the above source tapes. In the interest of efficiency, it is desirable that these programs operate with a common data format and with smaller subsets of the original data tapes. To meet these requirements, the original SUBSET program was developed. This program generates working subset tapes in ORSER format from the original source data tapes. As applied to aircraft MSS data, this facility has processed Houston C130 Bendix scanner data, in both LARSYS II and MSS-DAS formats, and Reconofax IV thermal scanner data. For the Image 100 project, SUBSET was extended to reformat data tapes compatible with the SUBSET program into ERTS format tapes. The actual format order in the program is SOURCE DATA - ORSER - ERTS. The result is a four-channel tape with 804 elements per scan line in ERTS format.

ERTS MSS digital data have been received in which data for some of the sensors have been nonconformable with data from the rest of the sensors, producing "banding" in the output and on standard single channel ERTS images. To investigate this problem, the SUBSET program has been extended to compute the mean and standard deviation for each channel for each line modulo six. It has become apparent that the problem has to do with calibration or processing of the data by NASA. It is also apparent that the data can be recalibrated, at least in an approximate way, by use of the MSS data alone. Two virtually cloud-free ERTS scenes over Pennsylvania, for which the data have been virtually useless because of non-conformable data in the third and fourth MSS channels, have been selected for recalibration.

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[1]MSS-DAS is the format system developed by NASA at the Johnson Space Flight Center, Houston, Texas

[2]LARSYS II is the format system used by the Laboratory for Agricultural Remote Sensing.

II. RELATED ACTIVITIES

Research

A study has been in progress to devise a method of specifying remotely sensed units for soil sample points. In this study, sites characteristic of three different soils have been selected in Lancaster, Lebanon, and Berks counties. Data over these sites were collected by a scanner flown by the Environmental Research Institute of Michigan, in May of 1969, and made available to ORSER by Dr. Harold T. Rib of the Federal Highway Administration. Color photographs were taken along the flight line simultaneously with MSS data collection. The digital data have been processed using ORSER programs, and bare soil training areas have been selected. These areas will be located on the ground and soil samples will be collected at each of three points in each field, located by scan line and element number on the output and by triangulation on the ground. The ground locations will be input to an RSU identification program which will output the remote sensing unit (scan line and element number) for each point. The degree of correlation between these RSU's and the ones originally chosen will be determined.

A contract has been signed with the Army Corps of Engineers to develop a technique using aircraft MSS and photographic data to delineate floodplain boundaries using natural indicators such as vegetation types, moisture stress, and soil types. The ultimate objective is to enable the USACE to reduce costly field surveys and improve accuracy and speed of floodplain delineation in vegetated areas. A section of the West Branch of the Susquehanna River has been chosen for this study.

Symposium

During December, six ORSER personnel attended the Third ERTS Symposium in Washington, D.C. A paper, PENN STATE ORSER SYSTEM FOR PROCESSING AND ANALYZING ERTS DATA, by McMurtry, Borden, Weeden, and Petersen, was presented.

Education

A color film entitled, "To Water by Air" is being planned, in cooperation with the Office of Public Information of The Pennsylvania State University and Hornbein Wood Film Studio of Lemont, Pennsylvania. The film will be designed for public information purposes to stress that often groundwater is available in large quantities in rocks where previously it was costly or difficult to obtain water on a low risk basis, and that new methods involving satellite and aircraft data are available to allow for the prospecting and efficient development of these water supplies.

Dr. Gold is offering a graduate level Geology/Geophysics course in Remote Sensing which presents a survey of remote sensing systems, theory, and applications. Results from some of the better student term

reports will be combined in an ORSER technical report. Individual lectures and introductory laboratory sessions in remote sensing have been conducted for various courses on the advanced undergraduate and graduate levels.

During December, Dr. Gold presented an open lecture on Remote Sensing and the Earth Resources program at the Penn State Schuylkill Campus. He also prepared a paper (with Drs. Parizek and Alexander) on satellite sensing platforms, imagery, scaling phenomena, and their utilization for resource evaluation in Pennsylvania, for the Earth and Mineral Sciences Bulletin, issued by Penn State. An ERTS display has been prepared and exhibited by ORSER in the Geological Sciences building on campus.

Contacts

Several staff members from the Susquehanna River Basin Commission and from the Susquehanna Economic Development Agency, in Pennsylvania, visited ORSER facilities and discussed project possibilities. A similar visit to ORSER was paid by members of the Regional Development Council of Northeastern Pennsylvania.

A former graduate student, Dr. Jack Krelling, now a geologist for Bethlehem Steel Corporation, visited ORSER with two Bethlehem Steel research scientists, with the objective of using the Bausch and Lomb Zoom Transferscope for coal exploration interpretations of large scale ERTS images.

The assistant director of the Pennsylvania Geologic Survey, and several personnel members of the Bureau of Materials of the Pennsylvania Department of Transportation, visited ORSER to review the data available and ORSER data processing techniques.

ORSER has hosted various individual visitors. Among them have been Dr. Ing. Lor Albertz of Germany, referred to ORSER by HRB Singer, Inc., and Dr. Charles E. Main of the Department of Plant Pathology at North Carolina State University.

Aircraft and satellite data available in the ORSER laboratory and computer files are finding growing use by outside agencies, such as a consulting geologist seeking clay deposits in the vicinity of Altoona, and the Clinton County Planning Commission, using aircraft IR film in determining damage from Hurricane Agnes along Blad Eagle Creek. Several technical reports are mailed each week in response to requests from engineering firms, professors, students, and agencies such as the Baltimore District Corps of Engineers.

III. DATA ACQUISITIONS

During this reporting period, the following aircraft data were received:

C130	Mission 230	MSS imagery
C130	Mission 258	Photography and preliminary MSS imagery
C130	Mission 238	Photography
C130	Mission 247	Photography
RB57	Mission 248	Photography